TP-02-0201
28744-138

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Milind Kulkarni Art Unit 1792
Serial No. 10/705,813
Filed November 10, 2003
Confirmation No. 5409
For CRYSTAL PULLER AND METHOD FOR GROWING A MONOCRYSTALLINE INGOT
Examiner Kunemund, Robert M.

APPEAL BRIEF

Michael G. Munsell, Reg. No. 43,820
ARMSTRONG TEASDALE LLP
One Metropolitan Square, 26th Floor
St. Louis, Missouri 63102
(314) 621-5070

TABLE OF CONTENTS

TABLE OF AUTHORITIES

REFERENCES

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Milind Kulkarni Art Unit 1792
Serial No. 10/705,813
Filed November 10, 2003
Confirmation No. 5409
For CRYSTAL PULLER AND METHOD FOR GROWING A MONOCRYSTALLINE INGOT
Examiner Kunemund, Robert M.

September 19, 2008

APPEAL BRIEF

This is an appeal from the final rejection of the claims of the above-referenced application made in the final Office action dated March 31, 2008. A Notice of Appeal was filed on July 30, 2008.

I. REAL PARTY IN INTEREST

The real party in interest in connection with the present appeal is MEMC Electronic Materials Inc., owner of a 100 percent interest in the pending application.

II. RELATED APPEALS AND INTERFERENCES

Appellants are not aware of any pending appeals, which may be related to, directly affect or be directly affected by, or have a bearing on, the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-17, 19, and 21-47 are currently pending in the application for consideration. A copy of the claims involved in this appeal appears in the Claims Appendix of this Brief.

Claims 1-17, 19, and 21-47 stand rejected.

The rejections of claims 1-6, 8, 10-12, 17, 19, and 21-47 are being appealed.

IV. STATUS OF AMENDMENTS

No amendments have been filed after the final rejection.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The following summary correlates claim elements to specific embodiments described in the application specification, but does not in any manner limit claim interpretation. Rather, the following summary is provided only to facilitate the Board's understanding of the subject matter of this appeal.

With reference to the present specification and drawings, claim 1 is directed to a crystal puller CP for growing monocrystalline ingots C according to the Czochralski method. See paragraph [0097], pages 15 and 16 and Figure 1. The puller CP comprises a housing H and a crucible CR in the housing for containing a semiconductor source material melt M. See paragraph [0097], pages 15 and 16 and Figure 1. The melt M has an upper surface MS. See paragraph [0097], pages 15 and 16 and Figure 1. A side heater SH is adjacent the crucible CR for heating the crucible CR. See paragraph [0107], page 20 and Figures 1 and 8. An elongate puller P has an end adapted to connect to the ingot C for pulling a growing ingot upward from the upper surface MS of the melt M. See paragraph [0097], pages 15 and 16 and Figure 1. A portion of the upper surface MS of the melt M remains exposed during growing of the ingot C. See paragraph [0098], page 16 and Figure 1. The exposed upper surface MS portion has an area. See paragraph [00100], page 17 and Figure 1. An annular melt heat exchanger MHE is sized and shaped for surrounding the ingot C and for being disposed adjacent the exposed upper surface MS portion of the melt M. See paragraph [0097], pages 15 and 16 and Figure 1. The heat exchanger MHE includes a heat source disposed to face the exposed upper surface MS portion of the melt M. See paragraph

[0097], pages 15 and 16 and Figure 1. The heat source has an area for radiating heat to the melt M sized at least 30% of the area of the exposed upper surface MS portion of the melt for controlling heat transfer at the upper surface of the melt. See paragraph [00100], page 17 and Figure 1. The melt heat exchanger MHE is adapted to reduce heat loss at the exposed upper surface MS portion. See paragraph [0099], page 17. The exposed upper surface MS portion of the melt M allows gases produced in the melt during heating thereof to exit the melt.

Claim 13 is directed to a reflector assembly R for use in a crystal puller CP for growing a monocrystalline ingot C from a semiconductor source material melt M. See paragraph [0097], pages 15 and 16 and Figure 1. The crystal puller CP has a housing H, a crucible CR contained in the housing for holding the source material melt M, a heater in thermal communication with the crucible for heating the crucible to a temperature sufficient to melt the semiconductor source material held by the crucible and a puller P positioned above the crucible for pulling the ingot C from the melt. See paragraph [0097], pages 15 and 16 and Figure 1. The reflector assembly R comprises a cover GC disposed above the melt M and has a central opening CO sized and shaped for surrounding the ingot C as the ingot is pulled from the melt. See paragraph [0097], pages 15 and 16 and Figure 1. A crystal heat exchanger CHE is at least partially inside the cover GC and adapted to be disposed above the melt M and substantially surround the ingot C for cooling a first segment of the growing ingot that is adjacent a melt/crystal interface F. See paragraph [0097], pages 15 and 16 and Figure 1. A melt heat exchanger MHE is at least partially inside the cover GC adapted to surround the ingot C proximate the surface of the melt for controlling heat transfer at the surface of the melt. See paragraph [0098], pages 16 and 17 and Figure 1. The

melt heat exchanger MHE is adapted to reduce heat loss at the uncovered surface. See paragraph [0099], page 17 and Figure 1.

Claim 17 is directed to a reflector R for use in a crystal puller CP for growing a monocrystalline ingot C from a semiconductor source material melt M. See paragraph [0097], pages 15 and 16 and Figure 1. The crystal puller CP has a housing H, a crucible CR contained in the housing for holding the source material melt M, a heater in thermal communication with the crucible for heating the crucible to a temperature sufficient to melt the semiconductor source material held by the crucible and a puller P positioned above the crucible for pulling the ingot from the melt. See paragraph [0097], pages 15 and 16 and Figure 1. The reflector R is disposed above the melt M and has a central opening CO sized and shaped for surrounding the ingot C as the ingot is pulled from the melt. See paragraph [0097], pages 15 and 16 and Figure 1. The reflector R comprises a crystal heat exchanger CHE sized and shaped for placement above the melt M and substantially surrounding the ingot C for cooling a first segment of the growing ingot proximate a melt/crystal interface F. See paragraph [0097], pages 15 and 16 and Figure 1. A lower crystal heater LH is disposed above the crystal heat exchanger CHE and substantially surrounding the ingot for maintaining a second segment of the ingot at a predetermined temperature. See paragraph [00123], page 28 and Figure 2.

Claim 21 is directed to method of growing a monocrystalline ingot C comprising forming a melt M of semiconductor source material in a crucible CR. See paragraph [0097], pages 15 and 16 and Figure 1. The melt M has a surface MS. See paragraph [0097], pages 15 and 16 and Figure 1. A heat source MHE is positioned to face the exposed upper surface portion of the melt M. See paragraph [0097], pages 15 and 16 and Figure 1. The

heat source MHE has an area for radiating heat to the melt M sized at least 30% of the area of the exposed upper surface portion of the melt. See paragraph [00100], page 17 and Figure 1. Semiconductor source material is pulled from the surface MS of the melt M such that the source material solidifies into a monocrystalline ingot C. See paragraph [0097], pages 15 and 16 and Figure 1. Heat transfer at the surface MS of the melt M is selectively controlled using the heat source MHE. See paragraph [0097], pages 15 and 16 and Figure 1. Gases produced in the melt M during heating thereof are allowed to exit the melt via the exposed upper surface of the melt.

Claim 32 is directed to a method of growing a monocrystalline ingot C using a crystal puller CP including a housing H, a crucible CR in the housing for containing a semiconductor source material melt M having a surface MS, a side heater SH adjacent the crucible for heating the crucible, and a melt heat exchanger MHE facing at least 30% of an exposed portion of the melt surface for heating the exposed portion. See paragraph [0097], pages 15 and 16, paragraph [00100], page 17, and Figure 1. The method comprises pulling the growing ingot C upward from the melt M. See paragraph [0097], pages 15 and 16 and Figure 1. A melt/ingot interface F is formed generally at a juncture of the ingot C and the melt surface MS. See paragraph [0097], pages 15 and 16 and Figure 1. The side heater SH and the melt heat exchanger MHE are simultaneously operated. See paragraph [00117], pages 25 and 26. The temperatures of the melt heat exchanger MHE and the side heater SH are controlled to control formation of defects within the ingot.

Claim 39 is directed to a method of growing a monocrystalline ingot C using a crystal puller CP including a housing H, a crucible CR in the housing for containing a

semiconductor source material melt M having an upper surface MS (see paragraph [0097], pages 15 and 16, and Figure 1), a side heater SH adjacent the crucible for heating the crucible (see paragraph [00107], page 20 and Figure 1), a pulling mechanism P for pulling a growing ingot C upward from the melt, a melt/crystal interface F being formed generally at the upper surface of the melt and having a shape (see paragraph [0097], pages 15 and 16, and Figure 1), an annular melt heat exchanger MHE including a heat source having an area for radiating heat to the melt sized at least 30% of the area of an exposed upper surface portion of the melt (see paragraph [00100], page 17), a crystal heat exchanger CHE surrounding the ingot and facing the ingot for removing heat from the ingot adjacent the melt/crystal interface (see paragraph [0097], pages 15 and 16, and Figure 1). The method comprises pulling the growing ingot C upward from the melt M (see paragraph [0097], pages 15 and 16, and Figure 1) and controlling an axial temperature gradient at the interface by manipulating a temperature field at the melt/ingot interface F (see paragraph [0098], page 16). Gases produced in the melt M during heating thereof are allowed to exit the melt via the exposed upper surface of the melt M.

Claim 44 is directed to a method of growing a monocrystalline ingot C using a crystal puller P including a housing H, a crucible CR in the housing for containing a semiconductor source material melt M having a surface MS (see paragraph [0097], pages 15 and 16 and Figure 1), a side heater SH adjacent the crucible for heating the crucible (see paragraph [00107], page 20 and Figure 1), and a melt heat exchanger MHE surrounding the ingot and facing an exposed portion of the melt surface (see paragraph [0097], pages 15 and 16 and Figure 1). The melt heat exchanger MHE includes a heat source having an area for radiating heat to the melt M sized at least 30% of the

area of an exposed upper surface portion of the melt M for heating the exposed portion and a lower heater LH for surrounding the growing ingot C. See paragraph [00100], page 17. The method comprises pulling the growing ingot C upward from the melt M. See paragraph [0097], pages 15 and 16 and Figure 1. A melt/ingot interface F is formed generally at a juncture of the ingot C and the melt surface MS. See paragraph [0097], pages 15 and 16 and Figure 1. The side heater SH, melt heat exchanger MHE, and lower heater LH are simultaneously operated. See paragraph [00123], page 28 and Figure 2. Heat radiated from the melt heat exchanger MHE and the side heater SH is controlled to control the interface shape. See paragraph [00111], page 23. Heat radiated from the lower heater LH is controlled to control the thermal history of segments of the growing ingot C. See paragraph [00145], page 39.

Claim 47 is directed to a crystal puller CP for growing monocrystalline ingots C according to the Czochralski method. See paragraph [0097], pages 15 and 16 and Figure 1. The puller CP comprises a housing H and a crucible CR in the housing for containing a semiconductor source material melt M. See paragraph [0097], pages 15 and 16 and Figure 1. The melt M has an upper surface MS. See paragraph [0097], pages 15 and 16 and Figure 1. A side heater SH is adjacent the crucible CR for heating the crucible. See paragraph [00107], page 20 and Figures 1 and 8. An elongate puller P has an end adapted to connect to the ingot C for pulling a growing ingot upward from the upper surface MS of the melt M. See paragraph [0097], pages 15 and 16 and Figure 1. A portion of the upper surface MS of the melt M remains exposed during growing of the ingot C. See paragraph [0098], page 16 and Figure 1. A reflector R is disposed above the melt M and has a central opening CO sized and shaped for surrounding the ingot C as the ingot is pulled from

the melt. See paragraph [0097], pages 15 and 16 and Figure 1. The reflector R includes a melt heat exchanger MHE at least partially inside the reflector adapted to surround the ingot C proximate the surface of the melt M for controlling heat transfer at the surface of the melt. See paragraph [0097], pages 15 and 16 and Figure 1. The melt heat exchanger MHE is adapted to reduce heat loss at the exposed surface MS. See paragraph [0097], pages 15 and 16 and Figure 1. A crystal heat exchanger CHE is at least partially inside the reflector R and disposed above the melt heat exchanger MHE. See paragraph [0097], pages 15 and 16 and Figure 1. The crystal heat exchanger CHE is adapted to substantially surround the ingot C for cooling a first segment of the growing ingot that is adjacent a melt/crystal interface F. See paragraph [0097], pages 15 and 16 and Figure 1. An upper heater UH is disposed above and outside the reflector R. See paragraph [00123], page 28 and Figure 2. A lower heater LH is disposed at least partially inside the reflector R and above the crystal heat exchanger CHE. See paragraph [00123], page 28 and Figure 2.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Appellants appeal the rejections of claims 1-6, 21-24, and 47 under 35 U.S.C. § 103(a) as being unpatentable over JP 63 008 291 (Ueya) in view of JP 11 043 396 (Okubo).

B. Appellants appeal the rejections of claims 8, 10-12, 17, 19 and 25-46 under 35 U.S.C. § 103(a) as being unpatentable over Ueya in view of U.S. Patent No. 6,117,402 (Kotooka et al.) and JP 11 255 577 (JP '577).

VII. ARGUMENT

A. Claims 1-6, 21-24, and 47 are submitted to be patentable over JP 63 008 291 (Ueya) in view of JP 11 043 396 (Okubo).

Claims 1-6

Claim 1 is directed to a crystal puller for growing monocrystalline ingots according to the Czochralski method. The puller comprises:

a housing;

a crucible in the housing for containing a semiconductor source material melt, the melt having an upper surface;

a side heater adjacent the crucible for heating the crucible;

an elongate puller having an end adapted to connect to the ingot for pulling a growing ingot upward from the upper surface of the melt, a portion of the upper surface of the melt remaining exposed during growing of the ingot, the exposed upper surface portion having an area; and

an annular melt heat exchanger sized and shaped for surrounding the ingot and for being disposed adjacent the exposed upper surface portion of the melt, the heat exchanger including a heat source disposed to face the exposed upper surface portion of the melt, the heat source having an area for radiating heat to the melt sized at least 30% of the area of the exposed upper surface portion of the melt for controlling heat transfer at the upper surface of the melt, the melt heat exchanger being adapted to reduce heat loss at the exposed upper surface portion, **the exposed upper surface portion of the melt allowing gases produced in the melt during heating thereof to exit the melt.** (Emphasis added).

Appellant's claimed puller recites that a portion of the upper surface of the melt remains exposed while the ingot is being grown to allow gases produced in the melt during heating to exit the melt. As a result, gases, such as oxygen, exit the melt and are prevented from being trapped in the melt. Trapped gases such as oxygen can negatively impact the quality of the ingot.

Claim 1 is nonobvious and patentable over the references of record, including JP Patent Application No. SHO 63-8291 (Ueya) in view of JP Patent Application Publication No. 11043396 (Okubo).

As shown in Fig. 1, Ueya discloses a semiconductor manufacturing apparatus having a gas tight vessel (41) and a melt tank (42) located in the vessel. An electric heater (52) is positioned inside the wall (43) of the melt tank (42) for melting a semiconductor base material to form a melt (51), and a liquid surface heating apparatus (60) is provided for maintaining the temperature of the upper layer of the melt (51). A cover liquid (53), such as a low-melting-point glass liquid or the like, covers the melt (51) for preventing "gasification" thereof. See page 4, second paragraph, last sentence of the translation of the Ueya reference. In other words, ***Ueya teaches that melt off-gases should be inhibited.***

As a result of the covering liquid, the melt of Ueya does not have a portion of its upper surface exposed during growing of the ingot. Instead, Ueya discloses that the melt is covered by a liquid to prevent "gasification". No portion of the upper surface of the melt of Ueya is exposed. The cover liquid increases the dissolved gas concentration in the melt by reducing the surface area available for transport and traps gases (e.g., oxygen) in the melt, rather than allowing the gases to leave the melt. The gases, such as oxygen, remain in the

system in high concentration where they can negatively impact the resulting ingot. See, for example, pages 3-5 of appellant's specification which discusses oxygen precipitation.

Accordingly, Ueya fails to teach or suggest a crystal puller having a portion of the upper surface of the melt remaining exposed during growing of the ingot that allows gases produced in the melt during heating thereof to exit the melt as recited in claim 1. In fact, Ueya teaches just the opposite: that ***melt off-gases should be inhibited.***

The Office relies on Okubo for disclosure of a crystal puller wherein off-gases are allowed to be removed. However, as explained in M.P.E.P. § 2145(X)(D) and § 2143.0(V), it is improper to combine prior art references if doing so would "render the prior art unsatisfactory for its intended purpose or change the principle of operation." Allowing off-gases as taught by Okubo goes against the very teachings of Ueya and would render Ueya's invention unsatisfactory for its intended purpose and change the principles of its operation.

Accordingly, claim 1 is nonobvious and patentable over Ueya and Okubo. Claims 2-6 depend from claim 1 and are patentable over Ueya and Okubo for at least the same reasons as claim 1.

Claims 21-24

Claim 21 is directed to a method of growing a monocrystalline ingot comprising:

forming a melt of semiconductor source material in a crucible, the melt having a surface;

positioning a heat source to face the exposed upper surface portion of the melt, the heat source having an area for radiating heat to the melt sized at least 30% of the area of the exposed upper surface portion of the melt;

pulling semiconductor source material from the surface of the melt such that the source material solidifies into a monocrystalline ingot;

selectively controlling heat transfer at the surface of the melt using the heat source; and

allowing gases produced in the melt during heating thereof to exit the melt via the exposed upper surface of the melt.

To the extent claim 21 recites the same features as claim 1, claim 21 is nonobvious and patentable over Ueya in view of Okubo for the same reasons as set forth above with respect to claim 1. In particular, claim 21 is directed to a method of growing a monocrystalline ingot comprising, in part, positioning a heat source to face the exposed upper surface portion of the melt and allowing gases produced in the melt during heating thereof to exit the melt via the exposed upper surface of the melt. As discussed in detail above, Ueya expressly teaches inhibiting gases produced in the melt during heating of the melt to escape the melt. Accordingly, claim 21 is patentable over Ueya in view of Okubo.

Claims 22-24 depend from claim 21 and are patentable over Ueya for at least the same reasons as claim 21.

<u>Claim 47</u>

Claim 47 is directed to a crystal puller for growing monocrystalline ingots according to the Czochralski method. The puller comprises:

a housing;

a crucible in the housing for containing a semiconductor source material melt, the melt having an upper surface;

a side heater adjacent the crucible for heating the crucible;

an elongate puller having an end adapted to connect to the ingot for pulling a growing ingot upward from the upper surface of the melt, a portion of the upper surface of the melt remaining exposed during growing of the ingot;

a reflector disposed above the melt and having a central opening sized and shaped for surrounding the ingot as the ingot is pulled from the melt, the reflector including a melt heat exchanger at least partially inside the reflector adapted to surround the ingot proximate the surface of the melt for controlling heat transfer at the surface of the melt, the melt heat exchanger being adapted to reduce heat loss at the exposed surface, and a crystal heat exchanger at least partially inside the reflector and disposed above the melt heat exchanger, the crystal heat exchanger being adapted to substantially surround the ingot for cooling a first segment of the growing ingot that is adjacent a melt/crystal interface;

an upper heater disposed above and outside the reflector; and

a lower heater disposed at least partially inside the reflector and above the crystal heat exchanger.

Claim 47 is submitted as patentable over the references of record including Ueya in combination with Okubo. Specifically, neither Ueya nor Okubo teaches or suggests a crystal puller having an upper heater and a lower heater. In fact, nowhere in the Office action does the Office even assert that either of the cited references teaches or suggests these features of claim 47. To establish a *prima facie* case of obviousness, the Office must show that each and every limitation of a claim is described or suggested by the prior art or would have been obvious based on the knowledge of those of ordinary skill in the art. *In re Fine*, 837 F.2d 1071, 1074 (Fed. Cir. 1988). In the case at hand, the Office has failed to show how each and every feature

of claim 47 is described or suggested by Ueya and/or Okubo and therefore has failed to establish a *prima facie* case of obviousness.

As explained in M.P.E.P. §2142, the Office bears the initial burden of factually supporting any *prima facie* conclusion of obviousness and, if the Office fails to produce a *prima facie* case, the appellant is under no obligation to submit evidence of nonobviousness.

Accordingly, claim 47 is submitted to be patentable over the references of record since the Office failed to establish a *prima facie* case of obviousness.

B. Claims 8, 10-12, 17, 19 and 25-46 are patentable over Ueya in view of U.S. Patent No. 6,117,402 (Kotooka et al.) and JP 11 255 577 (JP '577).

<u>Claims 8 and 10-12</u>

Claim 8 depends indirectly from claim 1 and further recites that a reflector includes insulation interposed between the melt heat exchanger and the melt. Claim 10, which depends indirectly from claims 1 and 8, recites that the crystal puller further comprises a lower crystal heater disposed above the crystal heat exchanger and adapted for substantially surrounding the ingot for maintaining a second segment of the ingot at a predetermined temperature. Claim 11 depends from claim 10 and recites that the crystal heat exchanger and the lower crystal heater are mounted in the reflector, the reflector further comprising insulation disposed between the crystal heat exchanger and the ingot and between the lower crystal heater and the housing. Claim 12, which also depends from claim 10, recites an upper crystal heater disposed above the lower crystal heater and

substantially surrounding the ingot for maintaining a third segment of the ingot at a predetermined temperature.

While each of these claims stands rejected as being obvious in view of Ueya in combination with U.S. Patent No. 6,117,402 (Kotooka et al.) and JP 11-255,577 (JP '577), nowhere in the Office action does the Office even mention the terms/phrases "insulation", "lower crystal heater", "upper crystal heater", or equivalents thereof. As a result, the Office has clearly failed to establish a *prima facie* obviousness case with respect to claims 8 and 10-12. Thus, the Office's rejection of these claims cannot be sustained.

Claim 17

Claim 17 is directed to a reflector for use in a crystal puller for growing a monocrystalline ingot from a semiconductor source material melt. The crystal puller has a housing, a crucible contained in the housing for holding the source material melt, a heater in thermal communication with the crucible for heating the crucible to a temperature sufficient to melt the semiconductor source material held by the crucible, and a puller positioned above the crucible for pulling the ingot from the melt. The reflector is disposed above the melt and has a central opening sized and shaped for surrounding the ingot as the ingot is pulled from the melt. The reflector comprising:

a crystal heat exchanger sized and shaped for placement above the melt and substantially surrounding the ingot for cooling a first segment of the growing ingot proximate a melt/crystal interface, and

a lower crystal heater disposed above the crystal heat exchanger and substantially surrounding the ingot for maintaining a second segment of the ingot at a predetermined temperature.

Claim 17 is nonobvious and patentable over the references of record, including Ueya in view of Kotooka et al. and JP '577, because the references fail to show or suggest a reflector including a crystal heat exchanger for cooling a first segment of the growing ingot proximate a melt/crystal interface and a lower crystal heater disposed above the crystal heat exchanger for maintaining a second segment of the ingot at a predetermined temperature.

Nowhere in the Office action does the Office assert that any of the cited references disclose a crystal heat exchanger and a crystal heater spaced above the crystal heat exchanger. Indeed, <u>each of the cited references fails to show or suggest a reflector including a lower crystal heater disposed above the crystal heat exchanger and substantially surrounding the ingot for maintaining a second segment of the ingot at a predetermined temperature as recited in claim 17</u>. Accordingly, the Office has failed to establish a *prima facie* case of obviousness with respect to claim 17.

As a result, claim 17 is nonobvious in view of and patentable over Ueya in view of Kotooka et al. and JP '577.

<u>Claim 19</u>

Claim 19 depends from claim 17 and recites that the reflector further comprises an upper crystal heater disposed above the lower crystal heater and substantially surrounding the ingot for maintaining a third segment of the ingot at a predetermined temperature. Nowhere does the Office assert that any of the cited references disclose or suggest an "upper crystal heater" as recited in claim 19. Indeed, <u>none of the cited references show or suggest an upper crystal heater as recited in claim 19</u>.

Accordingly, claim 19 is further patentable over Ueya in view of Kotooka et al. and JP '577.

Claims 25-46

Claims 25-46 stand rejected as being obvious in view of Ueya in combination with Kotooka et al. and JP '577. However, nowhere in the Office action does the Office assert that the features recited in these claims are taught or suggested by any one of the cited references. As a result, the Office has clearly failed to establish a *prima facie* case with respect to claims 24-31, and the Office's rejection of claims 24-31 cannot be sustained as presented in the Office action.

Claims 32-38

Claim 32 is directed to a method of growing a monocrystalline ingot using a crystal puller including a housing, a crucible in the housing for containing a semiconductor source material melt having a surface, a side heater adjacent the crucible for heating the crucible, and a melt heat exchanger facing at least 30% of an exposed portion of the melt surface for heating the exposed portion, the method comprising:

pulling the growing ingot upward from the melt, a melt/ingot interface being formed generally at a juncture of the ingot and the melt surface,

simultaneously operating the side heater and the melt heat exchanger, and

controlling the temperatures of the melt heat exchanger and the side heater to control formation of defects within the ingot.

The Office has failed to establish a *prima facie* case with respect to its rejection of claim 32. Nowhere in the Office

action does the Office assert that any one of the cited references teach or suggest the method steps recited in claim 32. Accordingly, the Office's rejection of claim 32 cannot be sustained.

Moreover, claim 32 is nonobvious and patentable over the references of record, including Ueya in view of Kotooka et al. and JP '577, because the references fail to show or suggest a method of growing a monocrystalline ingot including simultaneously operating the side heater and the melt heat exchanger.

In Ueya, <u>the crucible heater 52 and the heating apparatus 60 are not operated at the same time</u>. Instead, the crucible heater 52 is used to heat the melt tank 42 and cause melting. Once the melt 51 is formed, the crucible heater 52 is turned off and then the heating apparatus 60 is started to maintain the upper layer of the melt 51 at a specified temperature. See page 5, last paragraph of the translation. Accordingly, Ueya does not teach or suggest simultaneously operating a side heater and a melt heat exchanger as recited in claim 32.

Kotooka et al. and JP '577 are apparently not relied on by the Office as teaching the claimed side heater and melt heat exchanger.

Accordingly, claim 32 is submitted to be patentable over the combination of Ueya, Kotooka et al., and JP '577.

Claims 33-38 depend from claim 32 and are patentable over Ueya in view of Kotooka et al. and JP '577 for at least the same reasons.

<u>Claims 33-38</u>

Claims 33-38 stand rejected as being obvious in view of Ueya in combination with Kotooka et al. and JP '577. However, nowhere in the Office action does the Office assert that the

features recited in these claims are taught or suggest by any one of the cited references. As a result, the Office has clearly failed to establish a *prima facie* case with respect to claims 33-38, and the Office's rejection of claims 33-38 cannot be sustained as presented in the Office action.

Claim 39

Claim 39 is directed to a method of growing a monocrystalline ingot using a crystal puller including a housing. A crucible is in the housing for containing a semiconductor source material melt having an upper surface. A side heater is adjacent the crucible for heating the crucible. A pulling mechanism is for pulling a growing ingot upward from the melt. A melt/crystal interface is formed generally at the upper surface of the melt and has a shape. An annular melt heat exchanger includes a heat source having an area for radiating heat to the melt sized at least 30% of the area of an exposed upper surface portion of the melt. A crystal heat exchanger surrounds the ingot and faces the ingot for removing heat from the ingot adjacent the melt/crystal interface. The method comprises:

pulling the growing ingot upward from the melt; and

controlling an axial temperature gradient at the interface by manipulating a temperature field at the melt/ingot interface; and

allowing gases produced in the melt during heating thereof to exit the melt via the exposed upper surface of the melt.

The Office has failed to establish a *prima facie* case with respect to its rejection of claim 39 Nowhere in the Office action does the Office assert that any one of the cited references teach or suggest the method steps recited in claim 39. Accordingly, the Office's rejection of claim 39 cannot be

sustained. Moreover, as described in detail above with respect to claim 1, Ueya expressly teaches away from allowing gases produced in the melt during heating thereof to exit the melt via the exposed upper surface of the melt as recited in claim 39.

Claims 40-43 depend from claim 39 and are patentable over Ueya in view of Kotooka et al. and JP '577 for at least the same reasons as claim 39.

Claims 40-43

Claims 40-43 stand rejected as being obvious in view of Ueya in combination with Kotooka et al. and JP '577. However, nowhere in the Office action does the Office assert that the features recited in these claims are taught or suggested by any one of the cited references. As a result, the Office has clearly failed to establish a *prima facie* case with respect to claims 40-43, and the Office's rejection of claims 40-43 cannot be sustained as presented in the Office action.

Claims 44

Claim 44 is directed to a method of growing a monocrystalline ingot using a crystal puller including a housing, a crucible in the housing for containing a semiconductor source material melt having a surface, a side heater adjacent the crucible for heating the crucible, and a melt heat exchanger surrounding the ingot and facing an exposed portion of the melt surface. The melt heat exchanger includes a heat source having an area for radiating heat to the melt sized at least 30% of the area of an exposed upper surface portion of the melt for heating the exposed portion. A lower heater is for surrounding the growing ingot. The method comprises:

pulling the growing ingot upward from the melt, a melt/ingot interface being formed generally at a juncture of the ingot and the melt surface,

simultaneously operating the side heater, melt heat exchanger, and lower heater;

controlling heat radiated from the melt heat exchanger and the side heater to control the interface shape; and

controlling heat radiated from the lower heater to control the thermal history of segments of the growing ingot.

To the extent claim 44 recites the same features as claim 32, claim 44 is patentable over Ueya in view of Kotooka et al. and JP '577 for the same reasons as set forth above with respect to claim 32. That is, the references cited by the Office fail to show or suggest a method of growing a monocrystalline ingot including simultaneously operating the side heater and the melt heat exchanger.

Moreover, the Office has again failed to establish a *prima facie* case. Nowhere in the Office action does the Office assert that any one of the cited references teach or suggest the method steps recited in claim 44. Accordingly, the Office's rejection of claim 44 cannot be sustained.

<u>Claims 45 and 46</u>

Claims 45 and 46 stand rejected as being obvious in view of Ueya in combination with Kotooka et al. and JP '577. However, nowhere in the Office action does the Office assert that the features recited in these claims are taught or suggested by any one of the cited references. As a result, <u>the Office has clearly failed to establish a *prima facie* case with respect to claims 45 and 46, and the Office's rejection of claims 45 and 46 cannot be sustained as presented in the Office action</u>.

Claims 25-46

Claims 25-46 stand rejected as being obvious in view of Ueya in combination with Kotooka et al. and JP '577. However, nowhere in the Office action does the Office assert that the features recited in any of these claims are taught or suggested by any one of the cited references. See page 3 of the Final Office action.

As a result, the Office has clearly failed to establish a *prima facie* case with respect to claims 24-46, and the Office's rejection of claims 24-46 cannot be sustained as presented in the Office action.

CONCLUSION

For the reasons stated above, appellants respectfully request that the Office's rejections be reversed and that claims 1-17, 19, and 21-47 be allowed.

Respectfully submitted,

/Michael G. Munsell/

Michael G. Munsell, Reg. No. 43,820
ARMSTRONG TEASDALE LLP
One Metropolitan Square, 26th Floor
St. Louis, Missouri 63102
(314) 621-5070

MGM/PEB/tmg
Via EFS

VIII. CLAIMS APPENDIX

1. A crystal puller for growing monocrystalline ingots according to the Czochralski method, the puller comprising:

a housing;

a crucible in the housing for containing a semiconductor source material melt, the melt having an upper surface;

a side heater adjacent the crucible for heating the crucible;

an elongate puller having an end adapted to connect to the ingot for pulling a growing ingot upward from the upper surface of the melt, a portion of the upper surface of the melt remaining exposed during growing of the ingot, the exposed upper surface portion having an area; and

an annular melt heat exchanger sized and shaped for surrounding the ingot and for being disposed adjacent the exposed upper surface portion of the melt, the heat exchanger including a heat source disposed to face the exposed upper surface portion of the melt, the heat source having an area for radiating heat to the melt sized at least 30% of the area of the exposed upper surface portion of the melt for controlling heat transfer at the upper surface of the melt, the melt heat exchanger being adapted to reduce heat loss at the exposed upper surface portion, the exposed upper surface portion of the melt

allowing gases produced in the melt during heating thereof to exit the melt.

2. A crystal puller as set forth in claim 1 wherein the heat source has an area sized at least 40% of the area of the exposed upper surface portion of the melt.

3. A crystal puller as set forth in claim 1 wherein the heat source has an area sized at least 50% of the area of the exposed upper surface portion of the melt.

4. A crystal puller as set forth in claim 1 wherein the heat source has an area sized at least 60% of the area of the exposed upper surface portion of the melt.

5. A crystal puller as set forth in claim 1 wherein the heat source is adapted to be disposed within 50mm of the exposed surface of the melt.

6. A crystal puller as set forth in claim 1 wherein the heat source is adapted to be disposed within 30mm of the exposed surface of the melt.

7. A crystal puller as set forth in claim 1 further comprising a reflector supporting the melt heat exchanger.

8. A crystal puller as set forth in claim 7 wherein the reflector includes insulation interposed between the melt heat exchanger and the melt.

9. A crystal puller as set forth in claim 8 further comprising a crystal heat exchanger sized and shaped to be disposed above the melt and substantially surround the ingot for cooling a first portion of the growing ingot proximate a melt/crystal interface.

10. A crystal puller as set forth in claim 9 further comprising a lower crystal heater disposed above the crystal heat exchanger and adapted for substantially surrounding the ingot for maintaining a second segment of the ingot at a predetermined temperature.

11. A crystal puller as set forth in claim 10 wherein the crystal heat exchanger and the lower crystal heater are mounted in the reflector, the reflector further comprising insulation disposed between the crystal heat exchanger and the ingot and between the lower crystal heater and the housing.

12. A crystal puller as set forth in claim 10 further comprising an upper crystal heater disposed above the lower crystal heater and substantially surrounding the ingot for maintaining a third segment of the ingot at a predetermined temperature.

13. A reflector assembly for use in a crystal puller for growing a monocrystalline ingot from a semiconductor source material melt, the crystal puller having a housing, a crucible contained in the housing for holding the source material melt, a

heater in thermal communication with the crucible for heating the crucible to a temperature sufficient to melt the semiconductor source material held by the crucible and a puller positioned above the crucible for pulling the ingot from the melt, the reflector assembly comprising:

a cover disposed above the melt and having a central opening sized and shaped for surrounding the ingot as the ingot is pulled from the melt;

a crystal heat exchanger at least partially inside the cover and adapted to be disposed above the melt and substantially surround the ingot for cooling a first segment of the growing ingot that is adjacent a melt/crystal interface; and

a melt heat exchanger at least partially inside the cover adapted to surround the ingot proximate the surface of the melt for controlling heat transfer at the surface of the melt, the melt heat exchanger being adapted to reduce heat loss at the uncovered surface.

14. A reflector assembly as set forth in claim 13 further comprising a lower crystal heater disposed above the crystal heat exchanger and substantially surrounding the ingot for maintaining a second segment of the ingot at a predetermined temperature.

15. A reflector assembly as set forth in claim 13 wherein the reflector includes insulation interposed between the melt heat exchanger and the melt.

16. A reflector assembly as set forth in claim 15 wherein the reflector includes insulation interposed between the melt heat exchanger and the crystal heat exchanger.

17. A reflector for use in a crystal puller for growing a monocrystalline ingot from a semiconductor source material melt, the crystal puller having a housing, a crucible contained in the housing for holding the source material melt, a heater in thermal communication with the crucible for heating the crucible to a temperature sufficient to melt the semiconductor source material held by the crucible and a puller positioned above the crucible for pulling the ingot from the melt, the reflector being disposed above the melt and having a central opening sized and shaped for surrounding the ingot as the ingot is pulled from the melt, the reflector comprising:

a crystal heat exchanger sized and shaped for placement above the melt and substantially surrounding the ingot for cooling a first segment of the growing ingot proximate a melt/crystal interface, and

a lower crystal heater disposed above the crystal heat exchanger and substantially surrounding the ingot for

maintaining a second segment of the ingot at a predetermined temperature.

19. A reflector as set forth in claim 17 further comprising an upper crystal heater disposed above the lower crystal heater and substantially surrounding the ingot for maintaining a third segment of the ingot at a predetermined temperature.

21. A method of growing a monocrystalline ingot comprising:

forming a melt of semiconductor source material in a crucible, the melt having a surface;

positioning a heat source to face the exposed upper surface portion of the melt, the heat source having an area for radiating heat to the melt sized at least 30% of the area of the exposed upper surface portion of the melt;

pulling semiconductor source material from the surface of the melt such that the source material solidifies into a monocrystalline ingot;

selectively controlling heat transfer at the surface of the melt using the heat source; and

allowing gases produced in the melt during heating thereof to exit the melt via the exposed upper surface of the melt.

22. A method as set forth in claim 21 wherein said step of selectively controlling heat transfer includes cooperatively controlling heat transfer at the melt surface and the application of heat to the melt surface by positioning the heat source within 100 mm of the melt surface to selectively control defects within the ingot.

23. A method as set forth in claim 22 wherein the melt/ingot interface has a shape, the selective controlling step including varying the heat radiated from the melt heat exchanger to control the interface shape.

24. A method as set forth in claim 23 further comprising removing heat from the ingot at a location above a melt/ingot interface using a crystal heat exchanger.

25. A method as set forth in claim 24 wherein the heat removal step includes controlling the temperature of cooling fluid in the crystal heat exchanger to remove heat from the ingot at a predetermined rate and to maintain the ingot above a predetermined temperature.

26. A method as set forth in claim 25 further comprising allowing a portion of the ingot above the crystal heat exchanger to cool at a rate greater than the predetermined rate to control formation and/or growth of defects within the ingot.

27. A method as set forth in claim 24 wherein the selective control step includes controlling the temperature of the melt heat exchanger such that a segment of the ingot near the interface is cooled at a predetermined rate, the method further comprising removing heat from another segment of the ingot spaced from the interface at a rate greater than the predetermined rate.

28. A method as set forth in claim 27 wherein the selective control step includes controlling the temperature of the melt heat exchanger such that a segment of the ingot near the interface is cooled at a predetermined rate, the method further comprising removing heat from another segment of the ingot spaced from the interface at a rate greater than the predetermined rate.

29. A method as set forth in claim 24 further comprising heating a segment of the ingot spaced from the melt/crystal interface using a lower crystal heater disposed above the crystal heat exchanger.

30. A method as set forth in claim 29 further comprising heating a segment of the ingot spaced from the melt/crystal interface using an upper crystal heater disposed above the lower crystal heater.

31. A method as set forth in claim 21 wherein the method is free of a step of removing or adding a structural component of the crystal puller.

32. A method of growing a monocrystalline ingot using a crystal puller including a housing, a crucible in the housing for containing a semiconductor source material melt having a surface, a side heater adjacent the crucible for heating the crucible, and a melt heat exchanger facing at least 30% of an exposed portion of the melt surface for heating the exposed portion, the method comprising:

pulling the growing ingot upward from the melt, a melt/ingot interface being formed generally at a juncture of the ingot and the melt surface,

simultaneously operating the side heater and the melt heat exchanger, and

controlling the temperatures of the melt heat exchanger and the side heater to control formation of defects within the ingot.

33. A method as set forth in claim 32 wherein the controlling step includes controlling the side heater power in a predetermined range such that the temperature of the crucible is maintained below a predetermined temperature.

34. A method as set forth in claim 33 wherein the controlling step includes reducing heat loss from the melt

surface and simultaneously reducing the side heater temperature so as to reduce the temperature of the crucible.

35. A method as set forth in claim 32 wherein the melt/ingot interface has a shape, the controlling step including selecting a temperature of the melt heat exchanger to control the interface shape.

36. A method as set forth in claim 32 wherein the controlling step includes manipulating a temperature field at the melt/ingot interface.

37. A method as set forth in claim 32 further comprising selecting a desired axial temperature gradient, the controlling step including selecting a temperature of the melt heat exchanger to maintain the desired axial temperature gradient.

38. A method as set forth in claim 32 further comprising removing heat from the ingot at a location above the melt/ingot interface using a crystal heat exchanger.

39. A method of growing a monocrystalline ingot using a crystal puller including a housing, a crucible in the housing for containing a semiconductor source material melt having an upper surface, a side heater adjacent the crucible for heating the crucible, a pulling mechanism for pulling a growing ingot upward from the melt, a melt/crystal interface being formed generally at the upper surface of the melt and having a shape, an annular melt heat exchanger including a heat source having an

area for radiating heat to the melt sized at least 30% of the area of an exposed upper surface portion of the melt, a crystal heat exchanger surrounding the ingot and facing the ingot for removing heat from the ingot adjacent the melt/crystal interface, the method comprising:

pulling the growing ingot upward from the melt; and

controlling an axial temperature gradient at the interface by manipulating a temperature field at the melt/ingot interface; and

allowing gases produced in the melt during heating thereof to exit the melt via the exposed upper surface of the melt.

40. A method as set forth in claim 39 wherein the controlling step includes varying heat radiated from the melt heat exchanger and removing heat from the crystal using the crystal heat exchanger.

41. A method as set forth in claim 39 wherein the controlling step includes manipulating the temperature field to affect the shape of the interface.

42. A method as set forth in claim 39 wherein the controlling step includes manipulating heat radiated from a lower heater disposed above the crystal heat exchanger to control formation of defects in the growing ingot.

43. A method as set forth in claim 42 further comprising controlling heat radiated from an upper heater disposed above the lower heater to control formation and/or growth of defects in the growing ingot.

44. A method of growing a monocrystalline ingot using a crystal puller including a housing, a crucible in the housing for containing a semiconductor source material melt having a surface, a side heater adjacent the crucible for heating the crucible, a melt heat exchanger surrounding the ingot and facing an exposed portion of the melt surface, the melt heat exchanger including a heat source having an area for radiating heat to the melt sized at least 30% of the area of an exposed upper surface portion of the melt for heating the exposed portion, a lower heater for surrounding the growing ingot the method comprising:

pulling the growing ingot upward from the melt, a melt/ingot interface being formed generally at a juncture of the ingot and the melt surface,

simultaneously operating the side heater, melt heat exchanger, and lower heater;

controlling heat radiated from the melt heat exchanger and the side heater to control the interface shape; and

controlling heat radiated from the lower heater to control the thermal history of segments of the growing ingot.

45. A method as set forth in claim 44 further comprising controlling heat removed from the crystal by a crystal heat exchanger disposed to surround a segment of the ingot above the interface.

46. A method as set forth in claim 45 further comprising controlling heat radiated from an upper heater disposed above the lower heater for further controlling the thermal history of segments of the growing ingot.

47. A crystal puller for growing monocrystalline ingots according to the Czochralski method, the puller comprising:

a housing;

a crucible in the housing for containing a semiconductor source material melt, the melt having an upper surface;

a side heater adjacent the crucible for heating the crucible;

an elongate puller having an end adapted to connect to the ingot for pulling a growing ingot upward from the upper surface of the melt, a portion of the upper surface of the melt remaining exposed during growing of the ingot;

a reflector disposed above the melt and having a central opening sized and shaped for surrounding the ingot as the ingot is pulled from the melt, the reflector including a melt heat exchanger at least partially inside the reflector adapted to surround the ingot proximate the surface of the melt for

controlling heat transfer at the surface of the melt, the melt heat exchanger being adapted to reduce heat loss at the exposed surface, and a crystal heat exchanger at least partially inside the reflector and disposed above the melt heat exchanger, the crystal heat exchanger being adapted to substantially surround the ingot for cooling a first segment of the growing ingot that is adjacent a melt/crystal interface;

an upper heater disposed above and outside the reflector; and

a lower heater disposed at least partially inside the reflector and above the crystal heat exchanger.

IX. EVIDENCE APPENDIX

None.

X. RELATED PROCEEDINGS APPENDIX

None.